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SEASONAL QUANTITY DYNAMICS

of ground beetles on spring wheat under different fertilization systems

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Goal. *Determine the dominant species of ground beetles in crops of spring wheat with different fertilization systems and study the seasonal dynamics of the number of ground beetles.* ***Methods.*** *The research was conducted in 2017—2019 years on the experimental field of NSC «Institute of Agriculture of NAAS of Ukraine» in department of plant protection from pests and diseases. Accounting of carabids fauna in accordance with the generally accepted methodology, mainly using Barber soil traps. The ecological characteristics are given using literature data.* ***Results.*** *Specified species composition of the dominant species of carabids in spring wheat crops under different fertilization systems. Represented the seasonal quantity dynamics of mass species of carabids (Bembidion properans S., Harpalus affinis S., Harpalus rufipes D., Poecilus cupreus L., Harpalus distinguendus D.) with mineral ($N_{90}P_{60}K_{90}$) and organic (with plowing of by-products of the predecessor) fertilizer systems. Population peaks on spring wheat reached maximums in May due to an increase in the activity of species of the spring-summer group of ground beetles (Bembidion properans S., Harpalus distinguendus D., Poecilus cupreus L.), in June — July — due to the summer-autumn group (Harpalus rufipes D. and Harpalus affinis S).* ***Conclusions.*** *The peak activity of carabids in different areas is due to the peculiarities of the biology of each species during the growing season of spring wheat and weather conditions. Of the dominant, the most widespread species with mineral fertilizers was Bembidion properans S., with organic — Harpalus affinis S. There is a difference in the trophic specialization of beetles. In the areas with mineral fertilizer, the number of zoophages and myxophytophages was almost at the same level — 33.4 and 36.6 %, respectively. Organic fertilizer was dominated by myxophytophagous carabids (44%) with a mixed type of diet due to the largest number of species and the number of the genus Harpalus, the percentage of zoophagous was 14.5%.*

spring wheat; ground beetles; seasonal dynamics of activity; zoophagous; myxophytophages; trophic specialization; fertilizer system

Ground beetles play a significant role in biocenoses as entomophagous, regulating the number of terrestrial invertebrates, and are considered economically useful — adults and larvae destroy some pests of crops, limiting their numbers. In this regard, carabids can be used in biological methods of protection of forests and crops, which requires knowledge of their seasonal activity [1, 2]. Carabids are found in almost all land landscapes and respond subtly to changes in soil-plant and microclimatic conditions. These features have identified this group of animals as a convenient object for environmental research and as a bioindicator for environmental monitoring [3, 4]. Ground beetles also attract attention because they are active throughout the growing season. They can be considered as a constant natural press that affects phytophagous insects. Carabids are closely related to the surface and the top layer of soil and are the main part of geo- and herpetobiotic organisms [5]. This group of beetles is constantly attracting the attention of researchers because it represents active entomophagous in agrocenoses, the diversity and number of which can vary significantly throughout the growing season depending on crop, weather conditions or anthropic factors. Actively moving between different ecosystems, carabids are able to quickly restore their numbers in the fields [6, 7].

Material and methods of re-

Poecilus cupreus **L.**

Harpalus rufipes **Deg.**

Harpalus distinguendus **Duft.**

search. The study was conducted in 2017—2019 on the basis of National Research Center «Institute of Agriculture of NAAS of Ukraine», department of plant protection against pests and diseases (Chabany, Kyiv-Sviatoshynskyi district, Kyiv region).

Insects were counted every 10 days during the spring wheat growing season. Their number was determined using Barber soil traps (0.5 liter plastic containers, 1/3 filled with formalin 2—4%). This method makes it possible to obtain data on the dynamic population density of beetles, which consists of the total number of carabids in the area, as well as their activity. There were plots of 100 m^2 on spring wheat crops with mineral fertilizers ($N_{90}P_{60}K_{60}$) and plots with plowing of by-products of the predecessor (p.p.p).

The species composition of ground beetles was determined in laboratory conditions using tested insect determinants and electronic atlas [8, 9]. Trophic groups and seasonal activity of carabids are indicated in the literature [10, 11].

Results and discussion. 41 species of carabids from 15 genera were found in spring wheat crops, including 40 species (15 genera) in areas with mineral fertilizers and 32 species (12 genera) in organic fertilizers. According to the data in the carabids fauna, the most widely represented genera are *Harpalus* (11 and 10 species) and *Amara* (9 and 8), species with very wide trophic plasticity with mixed feeding, which prefer open areas [12]. All species of the genus *Amara* in the agrocenoses of spring wheat are few. The above-mentioned genera *Harpalus* and *Amara* occupy the first and second places in the list in terms of frequency of occurrence — more than 45—60% of all collected individuals of carabids.

Throughout the season, the dominant species in spring wheat crops were zoophagous *Bembidion properans* S., *Poecilus cupreus* L. and myxofytophagous *Harpalus affinis* S., *Harpalus rufipes* D., *Harpalus distinguendus* D. However, differences in the structure of the dominants were observed. According to the number of mass species of ground beetles in areas with mineral fertilizers (option 1) is 70%, organic (option 2) — 58.5% of the total number of carabids. In the areas with mineral fertilizer, the most widespread was the species *Bembidion properans* S. (18.6%), with organic — this species was as usual (3.2%). *Harpalus rufipes* D. (16.1%) had a lower percentage in the areas with mineral fertilizers, while *Harpalus affinis* S. and *Harpalus rufipes* D. were the most common in the areas with organic fertilizers (16.8% and 16.3%). *Harpalus distinguendus* D. was quite numerous in the areas of spring wheat with organic fertilizer — 10.9% (in areas with mineral fertilizer — 6.1%). Predatory carabid *Poecilus cupreus* L. had a larger share (14.8%) in areas with mineral fertilizers than with organic (11.3%).

In terms of seasonal activity of mass species in areas with mineral fertilizers, species with spring-summer type of activity dominate (39.5%) due to species *Bembidion properans* S. and *Poecilus cupreus* L.; with organic fertilizer — ground beetles of the summer-autumn group due to the largest number of species and the number of the genus *Harpalus.*

There are differences in trophic specialization. In areas with mineral fertilizers, zoophagous are numerous, the share of which is 33.4%, and myxophytophagous — 36.6%. A significant proportion of carabids (44%) in areas with organic fertilizer are species with a mixed type of feeding myxofytophages, the share of zoophages was 14.5%.

The dynamics of carabids activity changes during the growing season and depends on many factors: species biology, fertilizer system and weather conditions.

According to research, *Bembidion properans* S. is one of the mass and small zoophages on spring wheat, especially in areas with mineral fertilizer system, the number of species is 6 times higher than organic. In areas with mineral fertilizers carabids are active throughout the growing season, the maximum number was observed in mid-May — 11.8 exemplars for 10 trap days. In July, when the vegetative mass of spring wheat plants increases significantly, there is a sharp decline in the population of carabids of this genus. In areas with organic fertilizer, the number of *Bembidion properans* S. was much lower. In May, this species was more active, from June the number decreased sharply and was almost at the same level until the end of the growing season (fig. 1).

High population density (2.1 and 5.3 exemplars/10 trap days) of *Harpalus affinis* S. in both areas is observed in the second decade of May, increased numbers in the spring due to the emergence of overwintering adults with subsequent reproduction. The peak of the number in the areas with organic fertilizer was recorded in early June, the number decreases sharply by the second decade of June, the gradual growth of carabid is observed until mid-July. In areas with mineral fertilizers, the peak of *Harpalus affinis* S. was found in late June, which is almost two decades later than in areas with organic fertilizers. The high number of species in summer may be due to the conditions of existence and the presence of food plants (fig. 2).

At the end of May, a significant decline in the number of *Harpalus rufipes* D. species was observed

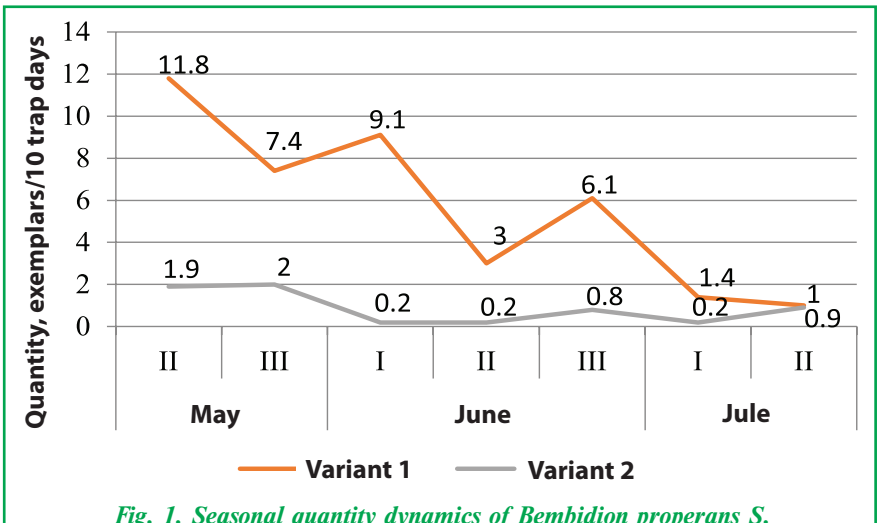


Fig. 1. Seasonal quantity dynamics of Bembidion properans S. on spring wheat under different fertilization systems (Chabany, Kyiv region, 2017—2019)

in both areas (mineral and organic fertilizer systems) of spring wheat — from 2.1 exemplars up to 0.4 exemplars, and from 0.9 to 0.3 exemplars/10 trap days (fig. 3). Dynamic activity of this species was observed from early June to mid-July. The peak of the number reached its maximum values in the second decade of July — 13.8 and 13.3 exemplars/10 trap days. This is due to the mass appearance of overwintering carabids of the summer-autumn group, which reproduce mainly in the second half of summer [13].

Poecilus cupreus L. was the dominant species in both areas. This predator easily adapts to changing living conditions. In mid-May, the activity of the predator was noted in both areas. The high number of insects according to years of research was with mineral fertilizers (fig. 4). At the end of May, the sharp decline in activity lasted only a decade and was at the same level until the end of the spring wheat growing season. Under conditions of organic fertilizer, the decline in the number of carabid lasted for two decades, after which it began to grow rapidly. The second peak of activity was recorded in the second decade of June, before the end of the growing season the number of carnivorous carabid gradually decreased. During the period of research during the seasonal dynamics, the number of adults was 1.5 times lower than organic food, except for the recorded peak, where the number was 1.6 times higher than the mineral. For organic fertilizers, the highest number was recorded in 2019 compared to 2017 and 2018 in 1.9 and 1.3 times, respectively. The maximum activity of *Poecilus cupreus* L. in mid-May is due to the additional nutrition required for egg formation. Due to global warming, the timing of insect development cycles may change, causing activity peaks to shift by 1—2 decades [14].

In areas with mineral fertilizers, the maximum number of *Harpalus distinguendus* D. was observed in the second decade of May, the decline occurred at the end of the growing season of spring wheat. Under the organic fertilizer system, two peaks of activity of this species were observed, the first peak was observed in late May, the second — in late June (fig. 5).

Thus, the number of species and the number of ground beetles du-

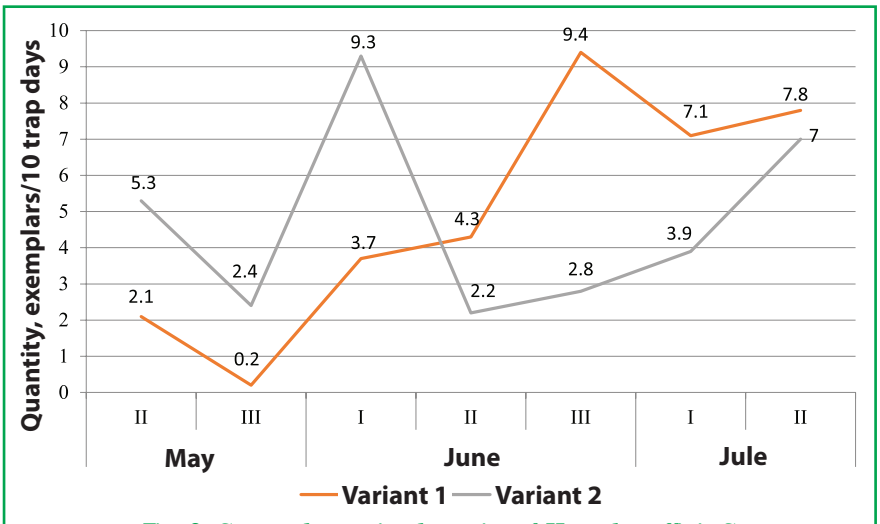


Fig. 2. Seasonal quantity dynamics of Harpalus affinis S. on spring wheat under different fertilization systems (Chabany, Kyiv region, 2017—2019)

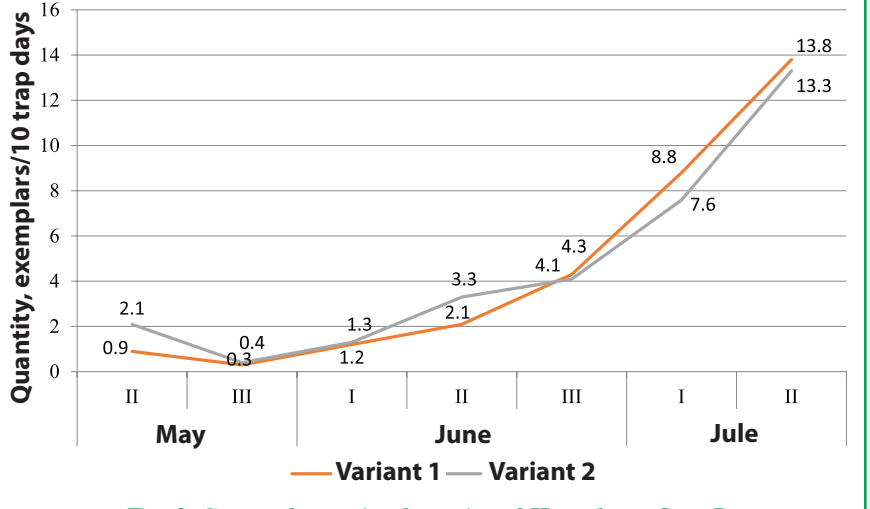


Fig. 3. Seasonal quantity dynamics of Harpalus rufipes D. on spring wheat under different fertilization systems (Chabany, Kyiv region, 2017—2019)

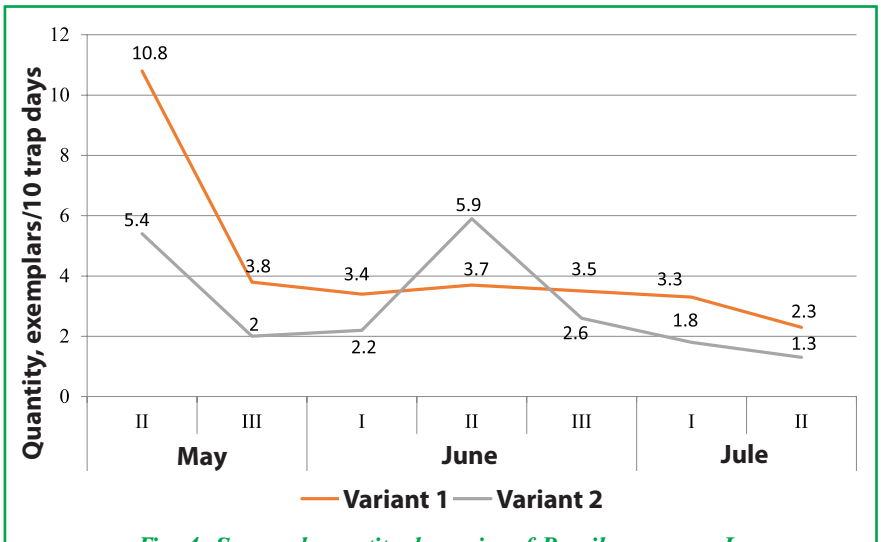


Fig. 4. Seasonal quantity dynamics of Poecilus cupreus L. on spring wheat under different fertilization systems (Chabany, Kyiv region, 2017—2019)

ring the season varied depending on the biology of each species, fertilizer system and weather conditions. At the beginning of the growing season, spring wheat was dominated by carabids with spring activity. At this time, spring wheat fields accumulate ground beetles from neighboring habitats, which leads to a high dynamic density of spring carabids populations, mainly in areas with mineral fertilizers, where vegetation is already more pronounced. At the end of the growing season, mainly in areas with organic fertilizer, carabids of the summer-autumn group, moderate mesophiles, which tend to relatively arid conditions and non-thickened crops, predominated.

It should be noted that there are differences in the number of ground beetles and years of research. Mass ground beetles in both areas were during the growing season only in 2017, their number was many times higher than in 2018 and 2019. Figure 6 shows that the air temperature in 2017 (late May-mid-June) was higher than normal by 0.4—2.7°C compared to long-term averages, but lower than in 2018, where the temperature was higher by 3—4.9°C, in 2019 — by 4.5—8.1°C. The only exception was *Harpalus affinis* S. in the organic fertilizer system, where the number of this species was many times higher in 2018 and 2019 compared to 2017, this species is more adapted to elevated air temperatures.

The change in the seasonal number of spring and summer species in the spring wheat agrocenoses was largely due to weather conditions. The number of spring-summer group of ground beetles *Bembidion properans* S., *Poecilus cupreus* L. in mid-May increased in warm weather with precipitation. Two peaks of the maximum number of *Poecilus cupreus* L. in the organic fertilizer system were observed only in 2017, so a clear pattern of the second peak of the number is not observed. The increased summer temperatures observed in recent years have affected the faster development of larvae of wintering carabids, and the periods of egg-laying of carabids have been shifted accordingly. The appearance of young beetles of the summer-autumn group was noted in May, but a mass release was observed in mid-July.

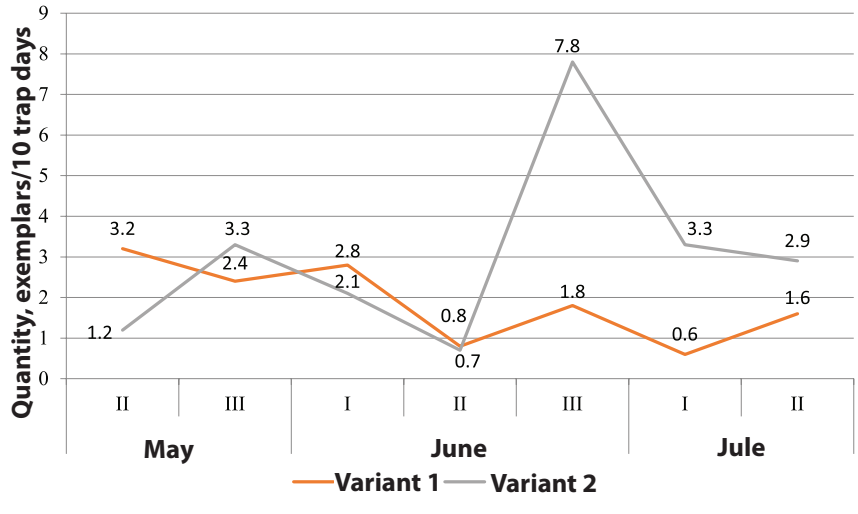
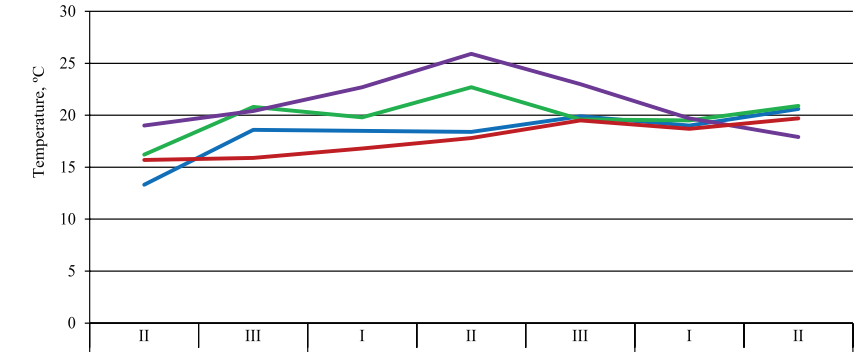


Fig. 5. Seasonal quantity dynamics of Harpalus distinguendus D. on spring wheat under different fertilization systems (Chabany, Kyiv region, 2017–2019)



	May		June			July	
	II	III	I	II	III	I	II
2017	13.3	18.6	18.5	18.4	19.9	19	20.6
2018	16.2	20.8	19.8	22.7	19.6	19.5	20.9
2019	19	20.4	22.7	25.9	23	19.7	17.9
norm	15.7	15.9	16.8	17.8	19.5	18.7	19.7

Fig. 6. Air temperature (average figures for decades), according to the weather station Chabany

CONCLUSIONS

The dominant species in the areas of spring wheat with different fertilization systems were zoophagous *Bembidion properans* S., *Poecilus cupreus* L. and myxofytophagous *Harpalus affinis* S., *Harpalus rufipes* D., *Harpalus distinguendus* D. According to the number of mass species of carabids in areas with mineral fertilizers is 70%, with organic — 58.5% of the total number of ground beetles.

Of the dominant species in the mineral fertilizer system, the most massive was the carnivorous carabid *Bembidion properans* S., of the organic — myxophytophag *Harpalus affinis* S. The dynamics of the number of mass species of ground beetles was characterized by several peaks, varying depending on biology, weather conditions and seasonal activity of carabids. In May, the number reached a maximum due to increased activity of the spring-summer group *Bembidion properans* S., *Harpalus distinguendus* D., *Poecilus cupreus* L. The second peak was in June — July due to the summer-autumn group *Harpalus rufipes* D. and *Harpalus affinis* S. Peaks of carabids activity in different areas are due to the mass emergence of beetles from wintering grounds and the presence of a trophic base during the growing season of spring wheat.

According to trophic specialization in the areas with mineral fertilizer, the number of zoophages and myxophytophages was almost at the same level of 33.4% and 36.6%, respectively. Myxophytophages carabids with mixed type of nutrition were more numerous (44%) in the organic fertilization system due to the largest number of species and the number of the genus *Harpalus*, the share of zoophagous was 14.5%.

REFERENCES

1. *Pisarenko V.N., Kolesnikov L.O., Nikolayeva S.A.* (2010). Khishchniki protiv vrediteley, zhuzhelitsy — ekologicheskiye druz'ya khleborobov. [Predators against pests, ground beetles — ecological friends of grain growers]. *Zerno.* № 9 (53). P. 40-44. [in Russian].

2. *Karpova V.E.* (1982). Rol' zhuzhelits v snizhenii chislennosti vrednykh nasekomykh na polyakh. [The role of ground beetles in reducing the number of harmful insects in the fields]. *Antropogennoye vozdeystviye na faunu pochv.* P. 91-96. [in Russian].

3. *Guseva O.G., Koval' A.G.* (2010). Pishchevyye svyazi zhuzhelits Pterostichus melanarius i Poecilus cupreus (Coleoptera Carabidae). [Food connections of ground beetles Pterostichus melanarius and Poecilus cupreus (Coleoptera Carabidae)]. *Vestnik zashchity rasteniy.* № 1. P. 61-63. [in Russian].

4. *Medvid Ya.A., Havryliuk N.M.* (2020). Vydovyi sklad turuniv (Coleoptera, Carabidae) na pshenytsi yarii u Pravoberezhnomu Lisostepu Ukrainy. [Species composition of carabids (Coleoptera, Carabidae) on spring wheat in the Right-Bank Forest-Steppe of Ukraine]. *Karantyn i zakhyst roslyn.* № 10-12. P. 7-11. [in Ukrainian].

5. *Puchkov A.V.* (2018). Zhuki-zhuzhelitsy (Coleoptera, Carabidae) transformirovannykh tsenozov Ukrainy. [Ground beetles (Coleoptera, Carabidae) of transformed cenoses of Ukraine]. Kiyev, 448 p. [in Russian].

6. *Sumarokov A.M.* (2009). Vosstanovleniye bioticheskogo potentsiala biogeotsenozov pri umen'shenii pestitsidnykh nagruzok. [Restoration of the biotic potential of biogeocenoses with a decrease in pesticide loads]. Donetsk: Veber. 194 p. [in Russian].

7. *Shushkivska N.I.* (2016). Zhuzhelytsi (Coleoptera, Carabidae) v biotsenozakh Tsentralnoho Lisostepu Ukrainy. [Ground beetles (Coleoptera, Carabidae) in the biocenoses of the Central Forest-Steppe of Ukraine]. *Ahrobiolohiia.* № 1 (124). P. 121-126. [in Ukrainian].

8. *Opredelitel' nasekomykh evropeyskoy chasti SSSR v pyati tomakh. Tom 2. ZHestkokrylyye i veyerokrylyye* (1965). [Keys to insects of the European part of the USSR in five volumes. Volume 2. Coleoptera and fan-winged]; pod red. G.YA. Bey-Biyenko. Moskva–Leningrad: Nauka. 668 p. [in Russian].

9. *Berlov O.* (2020). Atlas zhuzhelits (Carabidae) Rossii — kollektivnyy proyekt. [Atlas of ground beetles (Carabidae) of Russia — collective project]. URL:https://www.zin.ru/animalia/coleoptera/rus/atlascar.htm [in Russian].

10. *Sumarokov A.M.* (2002—2003). Izmeneniye vidovogo sostava i troficheskoy struktury koleopterofauny pri umen'shenii pestitsidnoy nagruzki na biotsenozy stepnoy zony Ukrainy. [Changes in the species composition and trophic structure of the coleopter fauna with a decrease in pesticide load on biocenoses of the steppe zone of Ukraine]. *Izvestiya KHar'kovskogo entomologicheskogo obshchestva.* Vol. 10, №1-2. P. 160-174. [in Russian].

11. *Puchkov O.V., Havryliuk N.M.* (2010). Osoblyvosti formuvannia struktury tverdokrylykh komakh (Insecta, Coleoptera) na perelohakh ta v ahrotsenozi ozymoi pshenytsi. [Peculiarities of formation of structure of hard-winged insects (Insecta, Coleoptera) on fallow lands and in agrocenosis of winter wheat]. *Karantyn i zakhyst roslyn.* №7 (169). P. 2-7. [in Ukrainian].

12. *Puchkov A.V.* (2012). ZHuzhelitsy roda Amara (Coleoptera, Carabidae) fauny Ukrainy. [Ground beetles of the genus Amara (Coleoptera, Carabidae) of the fauna of Ukraine]. *Vestnik zoologii.* Vol. 46, № 5. P. 395-413. [in Russian].

13. *Nikolenko N.Yu., Puchkov O.V.* (2020). Osoblyvosti sezonnykh zmin taksonomichnoi struktury i chyselnosti zhukiv-turuniv (Coleoptera, Carabidae) herpetobiiu urbotsenoziv m. Kharkova. [Peculiarities of seasonal changes in the taxonomic structure and number of ground beetles (Coleoptera, Carabidae) herpetobium of urbocenoses of Kharkiv]. *Bioriznomanittia, ekolohiia ta eksperymentalna biolohiia.* №22 (1). P. 56-66. [in Ukrainian].

14. *Pysarenko V.M., Koliesnikov L.O., Nikolaieva S.A.* (2011). Vplyv systemy zemlerobstva, yak ahroekolohichnoho faktora, na aktyvnist Poecilus cupreus l. (Coleoptera, Carabidae). [Influence of the agricultural system as an agroecological factor on the activity of Poecilus cupreus l. (Coleoptera, Carabidae)]. *Visnyk Poltavskoi derzhavnoi ahrarnoi akademii.* № 2. P. 7-13. [in Ukrainian].

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Сезонна динаміка чисельності турунів на посівах пшениці ярої за різних систем удобрення

Мета. *Визначити домінуючі види турунів у посівах пшениці ярої за різних систем удобрення та дослідити їхню сезонну динаміку чисельності.* ***Методи.*** *Дослідження проведено у 2017—2019 рр. на польовому стаціонарі ННЦ «Інститут землеробства НААН» у відділі захисту рослин від шкідників і хвороб. Обліки карабідофауни здійснювали за загальноприйнятими методиками, головним чином, з використанням ґрунтових пасток Барбера. Екологічна характеристика наведена з використанням літературних даних.* ***Результати.*** *Уточнено видовий склад домінуючих видів турунів у посівах пшениці ярої за різних систем удобрення. Наведено дані про сезонну динаміку чисельності масових видів турунів (Bembidion properans S., Harpalus affinis S., Harpalus rufipes D., Poecilus cupreus L., Harpalus distinguendus D.) за мінеральної ($N_{90}P_{60}K_{90}$) та органічної (із заорюванням побічної продукції попередника) систем удобрення. Піки чисельності на пшениці ярій сягали максимумів у травні за рахунок підвищення активності видів весняно-літньої групи турунів Bembidion properans S., Harpalus distinguendus D., Poecilus cupreus L., у червні — липні за рахунок літньо-осінньої групи Harpalus rufipes D. та Harpalus affinis S.* ***Висновки.*** *Пік активності турунів на різних ділянках зумовлений особливостями біології кожного виду в період вегетації пшениці ярої та погодними умовами року. З домінантних найбільш масовий на ділянках з мінеральним удобренням був вид Bembidion properans S., з органічним — Harpalus affinis S. Встановлено відмінність за трофічною спеціалізацією жуків. На ділянках з мінеральним добривом чисельність зоофагів і міксофітофагів була майже на одному рівні — 33,4 та 36,6%, відповідно. З органічним удобренням домінували туруни-міксофітофаги (44%) зі змішаним типом живлення за рахунок найбільшої кількості видів та чисельності роду Harpalus, частка зоофагів становила 14,5%.*

пшениця яра; туруни; сезонна динаміка активності; зоофаги; міксофітофаги; трофічна спеціалізація; система удобрення

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